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MECHANICAL AND THERMAL INVESTIGATIONS OF ALUMINIUM AL7075 ZIRCONIUM OXIDE AND GRAPHITE COMPOSITE MATERIAL

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ABSTRACT

In the world, existing materials are not sufficient to overcome the needs and to fulfil those needs, composite materials exist. The properties of composite materials are enhanced to overcome the needs. In this article, Aluminium is used as base material, whereas Zirconium Oxide and Graphite materials are used as additive materials at three composition percentage. The distribution of Zirconium Oxide and Graphite in base material Aluminium is investigated by Optical Microscope. Different composition of composite material is analysed for mechanical and thermal behaviour. As results concluded, composite material matrix of AL80%, ZrO15% and Graphite 5% has increased mechanical and thermal properties over other two composite materials such as increased hardness and tensile strength in the range of 66HRB and 138.66N/mm2, and the increased thermal conductivity is 215W/mk.

KEYWORDS: AL7075/ Zirconium Oxide and Graphite Metal Matrix Composite, Rockwell Hardness & Thermal Conductivity

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Original Article

INTRODUCTION

There are many matrix compositions like Metal matrix, Plastic matrix, fiber matrix etc. that are used to explain the composition of materials. These matrixes explain the grain structure and grain sizes of composite materials. Each and every matrix has their own advantage and applications over this widely used metal matrix, because of the properties like mechanical properties, electrical properties and thermal properties. Metal Matrix Composition has many applications in electronics and thermal management, when the composite material exhibits high thermal conductivity and proper thermal expansion.

[1] Inverse technique has an application for measuring Thermal Conductivity of composition like Carbon fiber Reinforced Polymer. Multidimensional mathematical models are used for simulating the spatial and temperature distribution of heat. Components of thermal conductivity tensor are equal, when fibers are assumed to be orthogonal [2]. Copper matrix composite materials with diamond particles are produced by high temperature-high pressure (HTHP) process at low cost. Titanium Carbide (TiC) increases the thermal conductivity of composite material further, while coating over the composite material. [3] Continuous fiber materials are structural materials and discontinuous and polymer-polymer reinforced composition are non-structural material. ZT values are high for non-structural material depending on composition, structure and method of preparation. Electrical Conductivity of the composite is high for structural material [4]. Increases in graphite content in aluminium matrix composition will

decreases densification due to particle size and graphite content. Addition of graphite in aluminium matrix increases thermal conductivity decreases the co-efficient of thermal expansion and increases thermal stability, showing that graphite content increases thermal properties of aluminium matrix composites [5]. Nanostructured and composite materials contributes towards energy industry development. Carbon Nano materials, metallic sulphides and titanium oxide are used for energy storage devices, where the energy storage for next generation is carried out. Nanostructured and composite materials are used for the purpose of energy storage for next generation [6]. Composite structure leads to failure due to high out of plane load components. Critical locations of composite structures are identified by using hot spot analyses. The art failure criterion is used for failure initiation for transversely isotropic composite materials [7]. Tensile test, Flexural test, impact test, Izod impact test, Compression test, Bending test, Cryogenic test, Shear test and Fatigue test are explained briefly [8]. Electrical conductivity of CPCM is increased due to addition of carbonaceous or metallic component. Silicon Carbide is used to enhance thermal conductivity of composite phase change materials. The thermal conductivity and mechanical strength of CPCM are increased by adding a suitable amount of Sic and decreases electrical conductivity [10]. TG analysis, PGC-MS analysis, an arc plasma ablation test, microstructural analysis and ATCM are evaluated for carbon-poly (Silacetylene) composites to investigate the chemical structures and thermal stability of poly (Silacetylene).

MATERIALS AND METHODOLOGY

Materials

Aluminium AL7075 is used as base material and two materials are used as additive materials such as Zirconium Oxide and Graphite. The various composition of materials used are Al 80% ZrO 5% Graphite 15%, Al 80% ZrO 15% Graphite 5% and Al 80% ZrO 10% Graphite 10%.

Aluminium Al7075

The most widely used and most frequently available material in earth is aluminium. Composition of AL7075 is 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper, and small traces of silicon, iron, titanium, chromium and manganese. The physical and mechanical properties are given below in Table 1.

Table 1: Properties of Aluminium AL7075

Properties	Values
Density	2.87g.cc.
Young's Modulus	70Gpa
Specific Heat Capacity	0.90 J/gc.
Thermal Conductivity	130 W/mk.

Zirconium Dioxide

Oxides of Zirconium are known as Zirconium Dioxide, which is known as white crystalline with a monoclinic structure. The properties of Zirconium Dioxide are given in Table 2 and the picture is given in figure 1.

Table 2: Properties of Zirconium Dioxide

PROPERTIES	VALUES
Density	6.15Mg/kg
Young's Modulus	100Gpa
Specific Heat Capacity	420J/kgk.
Thermal Conductivity	2.7W/mk.

Figure 1: Zirconium Dioxide.

Graphite

Graphite is used as reinforcement on account of its low constant of friction, glorious thermal physical phenomenon and corrosion resistance. Also, Carbon can act as a solid stuff for resistance applications, and making ready composites within built solid lubricating characteristics is a major importance for antifriction applications. The structure and picture of graphite is given in figure 2.

Figure 2: Graphite Material.

METHODOLOGY

Composites, additionally called fiber–reinforced chemical compound (FRP) composites are unit made up of a chemical compound matrix, that's bolstered and associated with nursing designed, synthetic or fiber (like glass, carbon or aramid) or other reinforcing materials. The matrix protects the fiber from environmental and external harm and transfer the load between the fibers. The fibers, in turn, give strength and stiffness to strengthen the matrix and facilitates it resist cracks and fracture. Composites are manufactured among one of the methods namely; Wet lay-up, Spray-up, Compression moulding, Injection moulding, Resin transfer moulding, Vacuum infusion, Filament winding, Pultrusion and Prepreg. Among these methods, compression moulding is used to prepare the composite.

The picture of Al 80% ZrO 5% Graphite 15% is shown in figure 3 and Al 80% ZrO 15% Graphite 5% is shown in figure 4 and Al 80% ZrO 10% Graphite 10% is shown in figure 5.

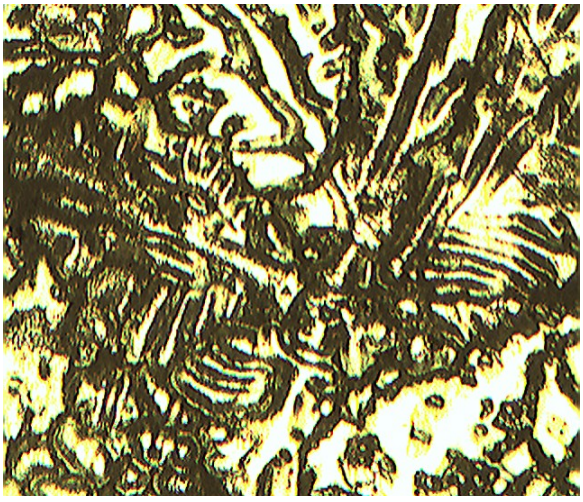

Figure 3: Picture of Al80% ZrO 5% Graphite 15%.

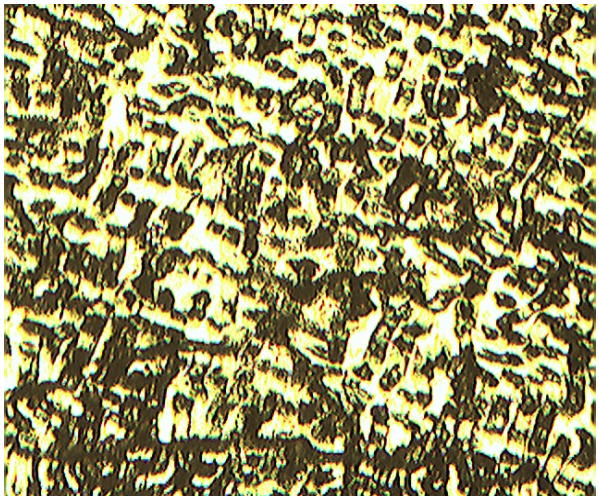

Figure 4: Picture of Al80% ZrO15% Graphite 5%.

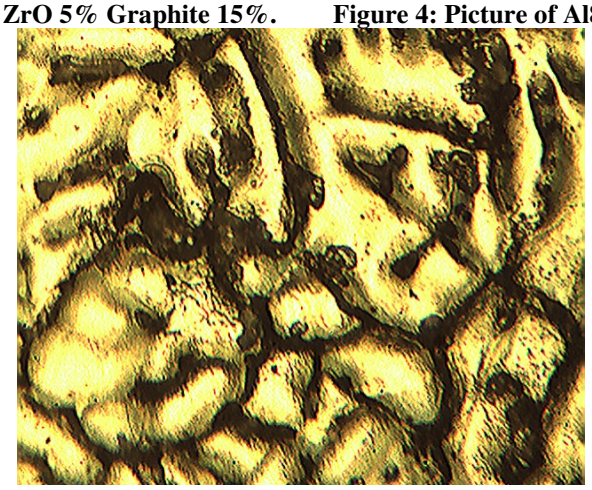

Figure 5: Picture of Al 80 % ZrO10% Graphite 10%.

RESULTS AND DISCUSSIONS

The various compositions of composite materials are carried out for mechanical and thermal analysis. A refers to Al80%, ZrO5% & Graphite15%, B refers to Al80%, ZrO15% & Graphite5%, and C refers to Al80%, ZrO10% & Graphite10%.

Mechanical Analysis

The mechanical analysis is carried out for various compositions of composite materials. The mechanical analysis consists of impact test, tensile test and elongation test.

Impact Test

Izod impact test is used to determine the impact strength. The impact strength of various composite materials is given below in figure 6.

From figure 6, the impact strength of composite material B is higher than other two materials because Zirconium Dioxide content in composite material B is higher compared to other two composite materials, so it induces the rise in impact strength which is around 0.42 N/mm2, which is comparatively 50% higher than the other two composite materials

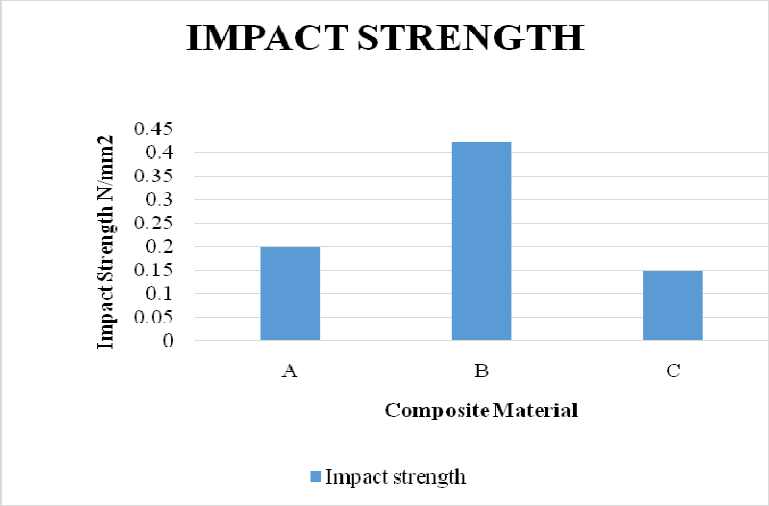

Figure 6: Impact Strengths of Various Composite Materials.

Tensile Test

Tensile test is used to determine tensile strength of a material. Tensile strength refers to ability of a material, which it can withstand when a tensile force is applied. Tensile strength of various materials is analysed by Universal Testing Machine (UTM). The variation of tensile strength for different composite material is given in figure 7.

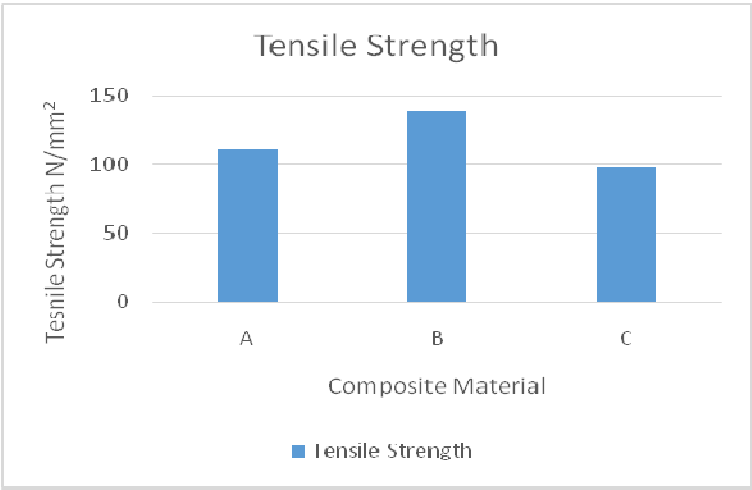

Figure 7: Tensile Strength of Various Composite Materials

In figure 7, the tensile test of various composite materials is shown. Tensile strength of various composite materials is compared between composition percentages of Zirconium and Graphite. Among these, 15% Zirconium 5% Graphite has higher tensile strength, because Zirconium has more resistance to withstand the fractures. So, composite material B has high tensile strength of 138.66N/mm^2.

Elongation

Elongation refers to a continuous deformation which the material can undergo. The variation in elongation between various composite materials is shown in figure 8.

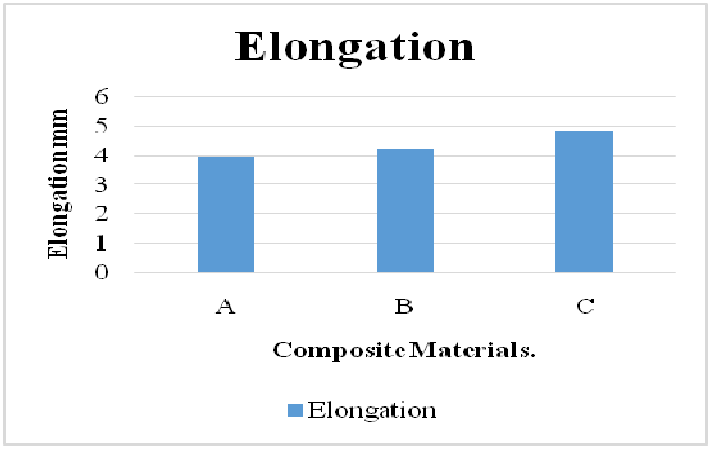

Figure 8: Elongation of Various Composite Materials.

The variation between various composite materials is shown in figure 8, in which, elongation is high for C type composite material while comparing with other two materials. Because both additive has elongation ability but graphite has little higher than zirconium. Due to this, the elongation is high for C type composite material of 4.83 mm.

Thermal Analysis

Thermal analysis is carried out for various types of composite materials, to find out the thermal behaviour of composite materials. In thermal analysis, thermal conductivity of various materials is found out, with respect to composition ratio as shown in figure 9.

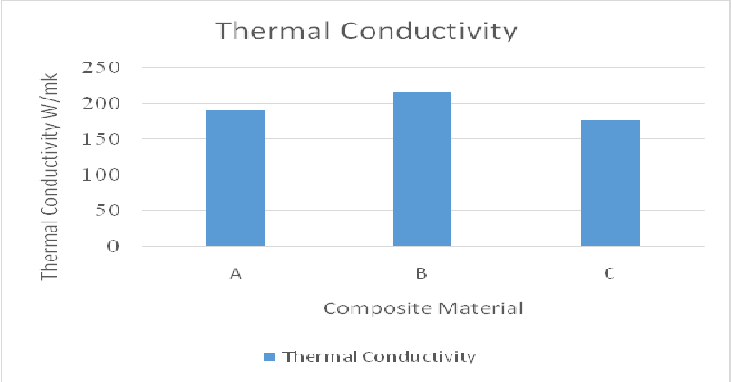

Figure 9: Thermal Conductivity of Various Composite Materials.

Figure 9 shows that thermal conductivity of B is higher than other composite material, in which thermal conductivity will increase by adding Zirconium content in composite material. In B, Zirconium content is 15%, so thermal conductivity of material gets increased because other two composite materials has less amount of Zirconium content comparing with B. So, it has high thermal conductivity in the range of 215 W/mk.

CONCLUSIONS

This article is based on development of aluminium alloy with the addition of different reinforcement in terms of varying percentage of composition. From the analysis, we concluded that among three types of aluminium composite materials, 80% of aluminium AL7075 with 15% of Zirconium with 5% of Graphite has higher mechanical and thermal properties with

other two composite material such as hardness of 66 HRD and tensile strength of 138.66 N/mm^2 and thermal conductivity of 215 W/mk. So, AL 7075 with 15% of Zirconium and 5% of Graphite has higher application in both mechanical and thermal due to its increased

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